

the Big Bang theory HSW7, 9, 10, 12

experimental evidence for the Big Bang theory from microwave background radiation at a temperature of 2.7 K HSW7, HSW11 The development and acceptance of Big Bang theory by the scientific community.

the idea that the Big Bang gave rise to the expansion of space-time

estimation for the age of the universe; $t = H_0^{-1}$ M2.4 HSW7

evolution of the universe after the Big Bang to the present HSW1, 2, 5, 6, 7, 8, 9, 10, 11

current ideas; universe is made up of dark energy, dark matter, and a small percentage of ordinary matter.

(6) M - Describe the big bang theory and the experimental evidence for it.
(7) S - Sequence and describe the evolution of the universe after the big bang
(8) C - Apply ideas about dark matter and dark energy to current thinking about the universe

Lesson 4. The big bang

SA

STARTER: The cosmological principle states that:

- The laws of physics are universal
- The universe is isotropic
- The universe is homogenous

Explain the meaning of each bullet point.

Kilo 10³

Mega 10⁶ Ex 1 - Explain the importance of each point to cosmology

Giga 10⁹

The laws of physics are universal.
The laws of physics can be applied everywhere in the universe. Theory and models tested on the Earth can be applied to everything within the universe over all time and space.

The universe is isotropic.
The universe looks the same in all directions

The universe is homogenous
Matter is distributed uniformly across the universe. For a very large volume the density of the universe is uniform

Sep 29-15:54

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the big bang (0-9 mins)

ACTIVITY 1: What is the **big bang theory**? Discuss and jot down ideas.
Summarise into 3 key characteristics.
Sequence the stages of evolution/composition from the big bang to present day

Kilo 10³ Support - Use the table to structure your evolution stages

Mega 10⁶ Ex 1 - When and why is the universe considered transparent?

Giga 10⁹

The big bang

- Creation of the universe, and the start of space and time.
- Initially very hot and dense.
- Universe is expanding and has led to the universe cooling.

Evolution of universe after big bang

- Time and space created.
- EM waves present
- super fast inflation of the universe
- Matter particles formed
- hot plasma of electrons, quarks.
- Cooling allows proton and neutrons to form from quarks.
- Electrons combine with protons to form atoms of hydrogen and helium.
- Hydrogen/helium gas coalesces under the force of gravity to form galaxies / nebula / protostars / stars
- Supernova form heavy elements.

Universe considered 'opaque' since EM radiation cannot pass through plasma without absorption

Universe considered 'transparent' since EM radiation can pass through atoms (with some characteristic frequencies absorbed)

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CMBR (0-5mins) 0:05:00

ACTIVITY 2: The universe was 3000K at the point of transparency. Use the black body spectrum graph for the CMBR to find the current temperature of the universe.
Explain why CMBR is experimental evidence for the big bang?

Kilo 10³ Support - Use Wien's law to find the temperature of the CMBR

Mega 10⁶ Ex 1 - How does the evidence from CMBR conform with the cosmological principle?

Giga 10⁹

Cosmic Microwave Background Spectrum from COBE

Wien's law states that the peak wavelength of the CMBR is inversely proportional to its temperature.
The temperature decrease by a factor of 1100.
If the wavelength of the CMBR has increase by a factor of 1100 also - therefore so must the universe since the moment of de coupling.

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cosmology revision 0:05:00

ACTIVITY 1:
Complete your SR and corrections

Kilo 10³ Support -

Mega 10⁶ Ex 1 -

Giga 10⁹

Key point

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cosmology revision 0:05:00

13 Which column A, B, C or D, shows the correct sequence for the evolution of the Universe between the Big Bang and the formation of stars?

A	B	C	D
Universe starts to expand	Universe starts to expand	quarks and leptons form	quarks and leptons form
quarks and leptons form	hadrons form	nuclei form	hadrons form
hadrons form	quarks and leptons form	Universe starts to expand	Universe starts to expand
nuclei form	nuclei form	atoms form	nuclei form
atoms form	atoms form	hadrons form	atoms form

Your answer ☐ [1]

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Plenary 0:05:00

State what is meant by the big bang. Describe how it explains the origin of the microwave background radiation.

In your answer, you should make clear how the microwave background radiation supports the Cosmological Principle.

Big bang: Creation of the universe (from which space/time evolved) (AW)
Any three from:
1. (At the start) the universe was hot / infinitely dense
2. Expansion of the universe led to cooling
3. The (current) temperature of universe is 2.7 K / 3 K
4. (The universe as a black body) is associated with microwaves at this temperature (AW)
or
The (wavelength of the) gamma radiation stretched to microwaves (by the expansion).

QWC: (Cosmological principle is supported because) MBR is isotropic

B1

B1 × 3

Not: The universe now has microwaves. (The microwaves must be linked with current temperature)

B1

Allow: Microwaves have the same intensity in all directions

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